



Introduction

Human physiology is the science concerned with the study of the normal functions of different parts of the human body.

The human body is composed of:

[Water (60%) / Proteins and related substances (20%) / Fat (15%) / minerals (5%) / carbohydrates (have little structural function but have major nutritional role)].

The cell membrane

It is a semipermeable flexible membrane that surrounds the cells and their organelles. It is composed of lipids (42%), proteins (55%), and carbohydrates (3%).

1] Lipids:

It covers the entire surface of the membrane. It forms a barrier for preventing the movements of water soluble substances. It is composed of:

a- Phospholipid bilayer: It is the major lipid in the membrane. It is composed of [hydrophilic head (water soluble) / hydrophobic tail (water insoluble)].

b- Cholesterol: it is dissolved in the phospholipid bilayer. It determines the flexibility and permeability of the membrane.

2] Proteins:

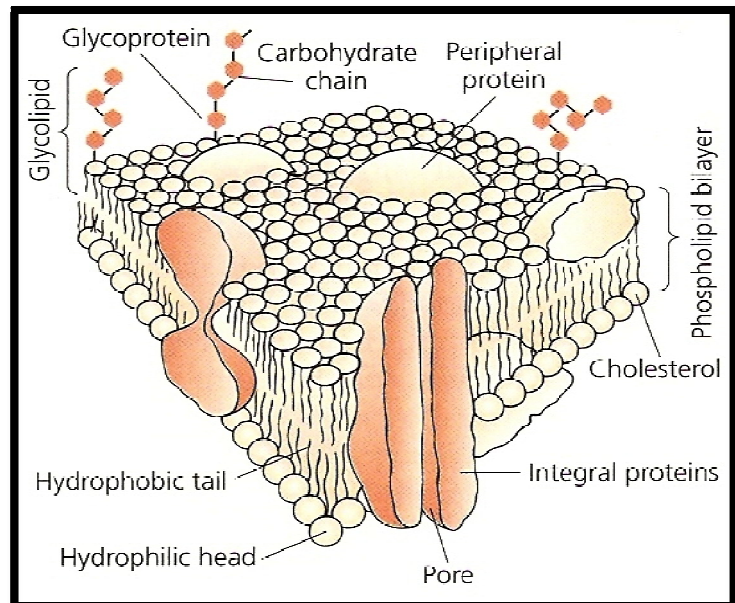
They present as globular masses in the lipid bilayer. They are of two types:

a- Integral proteins: they extend through the whole thickness of the membrane. Their functions include [ion channels, carriers (transporters), pumps, receptors, and enzymes].

b- Peripheral proteins: they do not extend through the whole thickness (attached to out or more commonly to the inside of membrane). They act mainly as enzymes.

3- Carbohydrates (glycocalyx):

The carbohydrates are present on the outer surface of membrane either attached to proteins (glycoprotein) or to lipids (glycolipid). They may act as receptors.



Intercellular communications

The cell may send its signals to (communicate with) another cell by one of the following:

1- Direct (electrical) communication:

It is by movement of electricity from one cell to another through the **gap junctions**.

These junctions are channels that run between the two connected cells. It is present in cardiac and smooth muscles.

2- Indirect (chemical) communication:

In this type, the signal (chemical substance) is secreted from the cell into the ECF to affect another cell by binding to its receptors. It is of 3 types:

a- Neural (synaptic): it is the secretion of chemicals (neurotransmitter) from the presynaptic to the post synaptic neurons through the synaptic cleft.

b- Endocrine: the cell secretes a substance (hormone) in the blood to affect far cells.

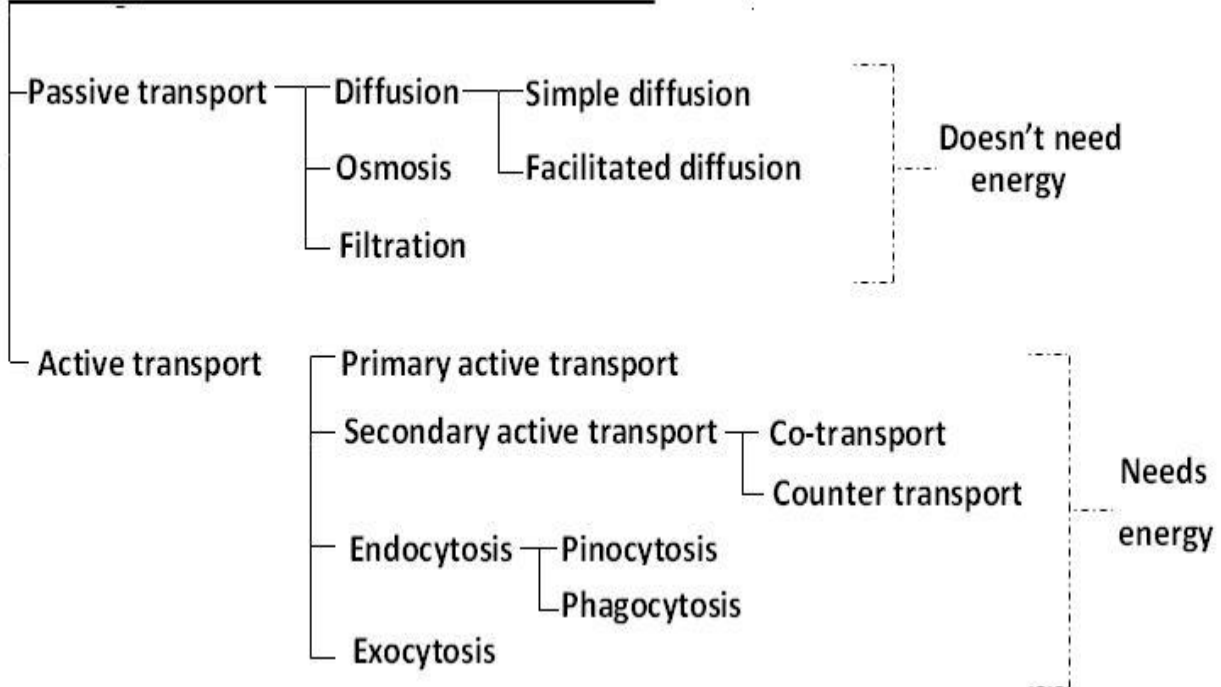
c- Paracrine: The cell secretes substances into ISF to affect nearby cells.

d- Autocrine: The substance affects the same cell that secreted it.

	GAP JUNCTIONS	SYNAPTIC	PARACRINE AND AUTOCRINE	ENDOCRINE
Message transmission	Directly from cell to cell	Across synaptic cleft	By diffusion in interstitial fluid	By circulating body fluids

Membrane transport

Transport across cell membrane



I] Passive transport

Diffusion: It is the transport of a substance across a semipermeable membrane down its electrochemical gradient (from high to low concentration, pressure, and/or voltage). It does not need energy.

The rate of transport of a substance (by diffusion) is:

a- Directly proportional with: [Concentration or electrical or pressure difference / Temperature / Surface area of the membrane / Permeability of the membrane].

b- Inversely proportional with: [Molecular Weight (size) of the substance / Thickness of the membrane].

The diffusion is of 2 types:

1] *Simple diffusion:*

It is the diffusion without need for carriers. It is for transport of:

a- Lipid soluble substances (e.g. O_2 & CO_2): They are transported passively through the phospholipid bilayer.

b- Small water soluble substances (e.g. Na^+ , K^+ , Cl^- , etc): They are transported passively through the protein channels.

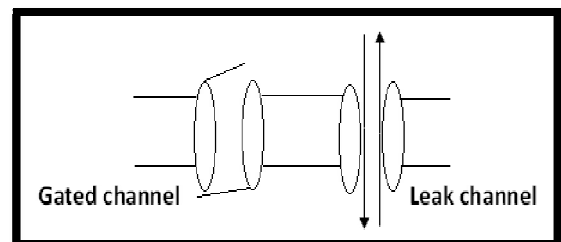
Types of channels in the membrane:

1- Leak channels: they are continuously opened. They are non specific [permit to the different ions to pass, but with some selectivity (one ion pass more than the other, i.e. the K^+ pass more than Na^+)].

2- Gated channels: these channels have gates (open and close). These channels are specific (permit only to specific ion to pass). These channels are named according to the factor that causes the opening of its gates:

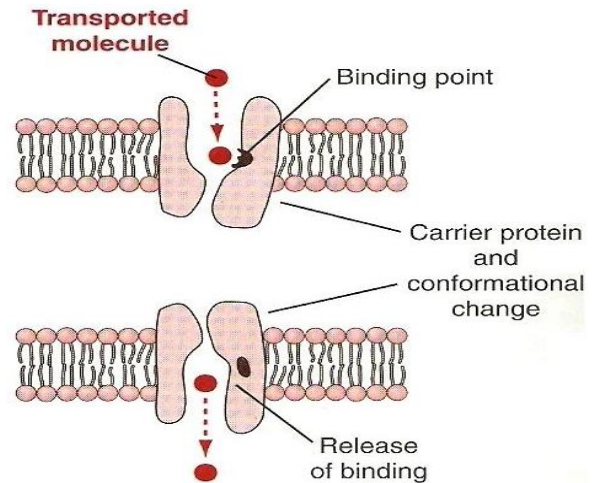
a- Voltage gated ion channels: these channels open in response to electrical changes.

b- Ligand gated ion channels: these channels open in response to binding of specific chemical substance (Ligand) to the receptor on this channel. Note that the substance that will pass through this channel is not the substance that caused the opening of its gates.



2] Facilitated (carrier mediated) diffusion:

It is the diffusion of substance that needs a carrier protein. It is for the transport of large lipid insoluble molecules (e.g. glucose, amino acids). Each carrier is specific for one or few substances. For this reason, the substance that are transported by carriers have a saturation level (when the all carriers that transport this substance are busy), in contrast to the transport by simple diffusion that has no saturation.



There are other special types of passive transport:

Osmosis: it is the diffusion of water across membrane from the area of its high concentration (less concentration of solute) to the area of its low concentration (high solute concentration) when this solute can not pass through this membrane.

Osmotic pressure: it is the pressure needed to stop osmosis. It depends on the number rather than the size of the particle of solute that caused to osmosis.

Filtration: it is the diffusion of fluid through a membrane due to difference in hydrostatic pressure (e.g. filtration of plasma through glomerular capillary in the kidney).

Note: The movement of a fluid across the capillaries wall (membrane) is controlled mainly by the effects of osmotic pressure [which pull it into the capillary from the ISF] & hydrostatic pressure [which push it from the capillary into the ISF].

II] Active transport

It is the transport of a substance through a membrane against electrochemical gradient (from low to high concentration or electrical or pressure gradient). It needs energy.

1- Primary active transport: it is the transport of a substance actively by a protein called pump. This pump has ATP ase activity, i.e. can hydrolyze the ATP and extract the energy directly from it. Examples of these pumps are:

a- Na-K pump: it presents in the membrane of all cells of the body. It pumps 3 Na⁺ outside and 2 K⁺ inside the cell.

b- Calcium pump: present in the cell membrane, mitochondria membrane & in the membrane of sarcoplasmic reticulum.

2- Secondary active transport: it is the transport of a substance (actively) secondary to the transport of another substance (passively). The actively moved substance extract the energy indirectly from the kinetic energy generated during the passage of the other substance passively. It is of 2 types:

a- Co-transport: the two substances are transported in the same direction [e.g. sodium – glucose transport in the renal tubules].

b- Counter transport: the two substances are transported in opposite directions [e.g. Na⁺ – H⁺ transport in renal tubules].

3- Endocytosis:

It is the transport of macromolecules (proteins or bacteria) to inside the cell. It is either:

a- Pinocytosis (cell drinking).

b- Phagocytosis (cell eating).

4- Exocytosis (cell excretion):

it is the process by which the macromolecules are transported to the outside of the cell.

Body water

The water constitutes about 60% of the body weight (about 42 L in 70kg person).

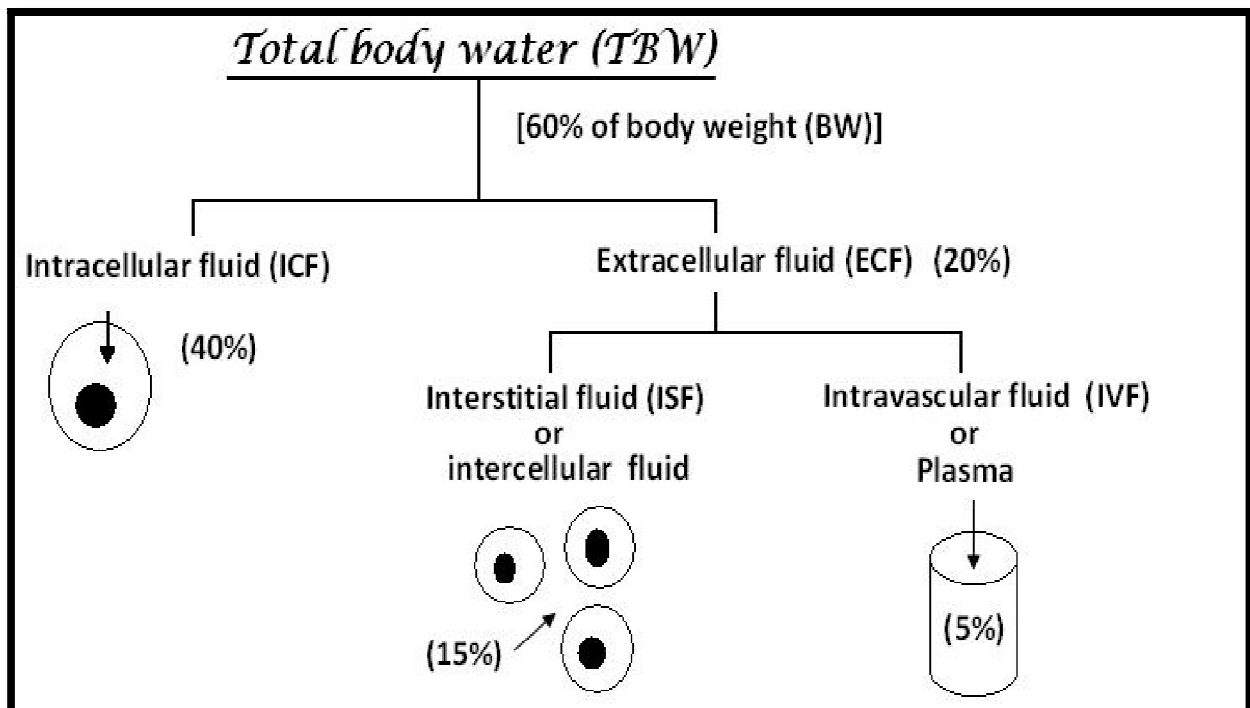
The water in the body is distributed in 2 compartments:

1- Intracellular fluid (ICF): it is the fluid (water) present inside the cell. It constitutes about 40% of the body weight (2/3 of the total body water).

2- Extracellular fluid (ECF): it is the fluid present outside the cell. It constitutes about 20% of body weight (1/3 of the total body water). It is divided into:

a- Interstitial fluid (ISF): it is present between cells. It is about 15% of the BW.

b- Intravascular fluid (plasma): it is present inside the blood vessels. It is about 5% of BW.



Note: the ECF (ISF & plasma) called the internal environment of the body.

These ratios are in adult average weight male, and there are normal variations for its distribution that change with:

1- **Age:** the TBW is more in infants and children (about 75%), and decrease with ageing to reach (about 45%) in elderly.

2- **Sex:** the TBW is less in females (about 50%) than males, because the females have high fat content.

3- **Fat content:** TBW is less in obese persons (because they have more fat).

Distribution of ions in the body compartments:

	ICF	ECF
<u>Cations</u> (+ve ions)		
Na+	14	140
K+	140	4
Ca++	0.0001	2.4
<u>Anions</u> (-ve ions)		
Cl-	4	104
HCO ₃ ⁻	10	28
Phosphate (PO ₄ ⁻³)	75	4
proteins	40 (16 gm%)	4 (2 gm%)

Homeostasis

Definition: it is keeping the internal environment of the body (ECF) constant regarding [Volume (water content) / Ions concentration / Temperature / PH] to make it optimum for cellular function.

These parameters are kept in their physiological levels by most of the systems in the body that act as *homeostatic control systems*. The functions of these systems are regulated by rapid control system (nervous system) and slow control system (endocrine system).

Feedback control in homeostasis: it is the control of certain function by the resultant effect of this function.

1- Negative feedback: in which the resultant effect of a function inhibits that function (the effect is opposite to the stimulus that caused it). It leads to stability of the internal environment.

2- Positive feedback: in which the resultant effect of a function stimulates that function (the effect is the same as the stimulus that caused it). It usually leads to instability or may lead even to death (as in heart failure), but can sometimes be useful (as in labor and blood coagulation).

